Appendix C

Estimating Potential Monetary Benefits Under Alternative B (Implement Benefits-Sharing)

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C.1 Introduction

Chapter 4's analysis of the potential quantitative impacts of Alternative B on natural resource management is based on the possible monetary benefits that could be generated under benefits-sharing agreements (*see* Chapter 4, Section 4.2). This appendix describes and estimates potential monetary benefits resulting from implementation of Alternative B.

The National Park Service has reviewed the experience of federal laboratories and academic institutions related to the commercial use of research results as described in Chapter 1, Sections 1.9.1 (Federal Technology Transfer) and 1.9.2 (Academic Technology Transfer). Annual reports about income generated by licenses held by federal laboratories are compiled by the U.S. Department of Commerce (DOC).[1] The analysis below uses a five-year dataset, FY1999–FY2003, as reported in the DOC's 2004 Summary Report on Federal Laboratory Technology Transfer. Annual reports about income generated by licenses held by academic institutions are compiled by the Association of University Technology Managers (AUTM).[2] A four-year dataset, FY1999–FY2002, from AUTM's Licensing Survey Report for 2002, was analyzed and is presented below.[3]

C.2 Monetary Benefits Types: Up-Front and Performance-Based

Two types of monetary benefits could occur under Alternative B: up-front payments and performance-based payments.

C.2.1 Up-Front Payments

The Federal Technology Transfer Act of 1986 (FTTA) authorizes private-sector research partners to provide funds through CRADAs to be used to support the participating federal laboratory's research activities consistent with its mission. This DEIS terms such payments "up-front payments."

Not all benefits-sharing agreements would generate up-front payments. Some benefits-sharing agreements could provide up-front payments before any research result actually yielded income for the researcher's institution.

C.2.2 Performance-Based Payments

Performance-based payments would likely be due to the NPS whenever (and if) the researcher's institution derived any kind of income from research results. The rate at which performance-based payments would be paid to the NPS would be established in the mutually agreed terms of a benefits-sharing agreement.

Income can be produced in a number of ways; one occurs when intermediate research results are licensed to another institution (license income). Licenses can generate income for the researcher's institution through royalties based, for instance, on product sales (royalty income from licensing), or through other means such as license issue fees, annual minimum

payments, or milestone payments (payments based on successful completion of certain research and development stages, described in Chapter 3, Section 3.4.3).

Income can also be produced by the performance of contract research, such as when a researcher screens compounds for particular characteristics, or if research results are developed fully for the marketplace. For example, a researcher's major source of income could be derived from performing research for others under contract using proprietary methods the researcher developed from study of NPS research specimens.

C.3 Monetary Benefits Timing

A benefits-sharing agreement could generate monetary benefits during the immediate benefits period, the deferred benefits period, both periods, or neither period. These possibilities are summarized in Figure C.3. For this DEIS, immediate benefits are those that occur during the initial five-year term of an agreement. Deferred benefits are those that occur after the initial five-year term of an agreement.

Figure C.3. Potential Monetary Benefits of a Single Benefits-Sharing Agreement

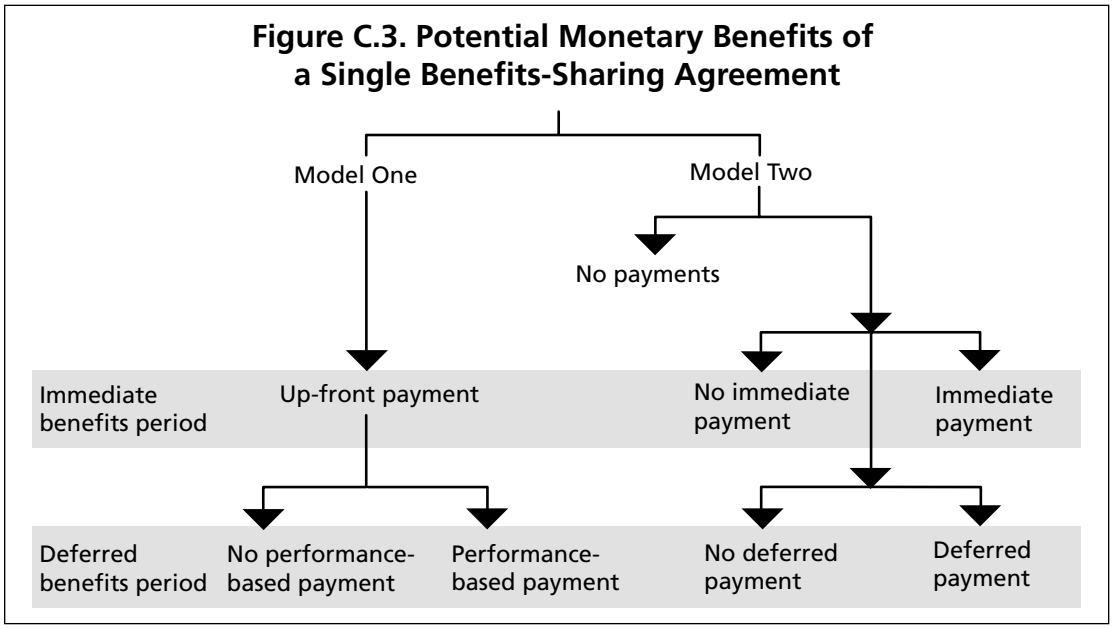

Figure C.3. A benefits-sharing agreement could generate monetary benefits during either the immediate benefits period, the deferred benefits period, both periods, or neither period.

C.3.1 The Immediate Benefits Period

For purposes of analysis, each benefits-sharing agreement's obligation to provide immediate benefits to the NPS was assumed to expire after five years. This estimate was based on examination of the average duration of CRADAs and academic technology transfer licenses. Although actual benefits-sharing agreements could be negotiated to provide immediate monetary benefits during longer or shorter periods, and could be extended for additional immediate benefits periods, a five-year average immediate benefits period was used in this DEIS for modeling potential monetary benefits.

Table C.3.1 displays information about the average duration of CRADAs (*see* Appendix G) and AUTM licenses (termed here "agreements"). The number of agreements active each year was divided by the number of new agreements executed each year to determine the average duration of agreements. On average, though the duration of CRADAs is less than the duration of AUTM licenses, 23% of all agreements were newly executed each year. Therefore, the average agreement duration is greater than four years.

Table C.3.1. Average duration of CRADAs and AUTM licenses[4]

	FY1999	FY2000	FY2001	FY2002	FY2003	Total CRADAs/ years 1999–2003	Average duration of agreements
New CRADAs	1,023	904	926	2,582	2,748	8,183	
Active CRADAs	3,227	3,133	3,670	5,325	5,551	20,906	2.6 years
	FY1999	**FY2000**	**FY2001**	**FY2002**		**Total licenses/ years 1999–2002**	**Average duration of agreements**
New AUTM licenses	3,914	4,362	4,058	4,673		17,007	
Active AUTM licenses	18,617	20,968	22,937	26,086		88,608	5.2 years
						Total agreements/ years 1999–2002	
					New CRADAs and licenses	25,190	
					Active CRADAs and licenses	109,514	4.3 years

Table C.3.1. Federal laboratory CRADAs and AUTM licenses are active for an average of greater than four years.

The only example of a benefits-sharing agreement negotiated by an NPS unit is the Yellowstone–Diversa CRADA. The immediate benefits period in that CRADA was five years, with additional five-year periods possible, subject to agreement renewal. Accordingly, the analysis in this DEIS is based on a five-year immediate benefits period.

C.3.2 The Deferred Benefits Period

Due to the lag time between discovery and each subsequent stage of research and development (R&D) (*see* Chapter 3, Section 3.4.3), most performance-based payments would generally not occur immediately upon entering into a benefits-sharing agreement. AUTM has concluded that the age of a program is a significant factor in evaluating performance because of several variables, including the time needed to develop and market products after discoveries have been made.[5]

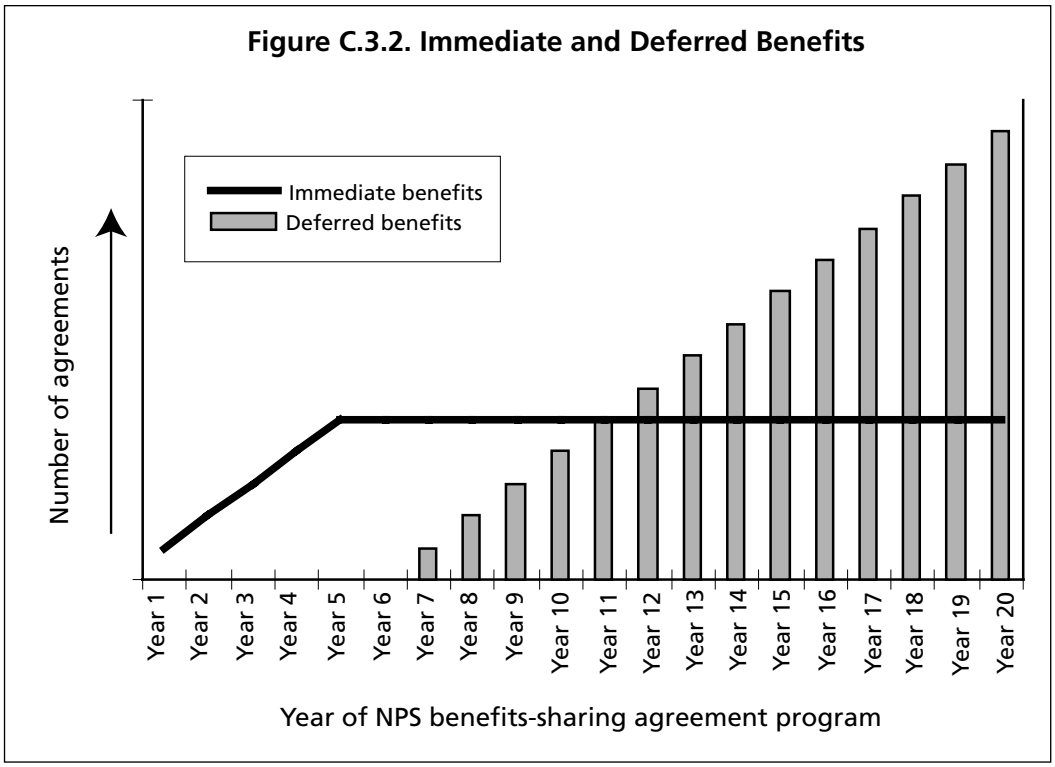

Figure C.3.2. Each agreement's obligation to provide immediate benefits would expire, but its obligation to provide performance-based payments through the 20-year DEIS analysis period would continue. As the years pass, more agreements each year might generate deferred benefits. (See Section C.7 and Table C.7.3 for a detailed presentation of the concepts illustrated in this figure.)

Performance is influenced by complex factors, including the irregular pace at which R&D yields new knowledge and inventions.[6] For example, development of new medicines can require 15 years or more between the discovery stage and the marketing stage.[7] Other commercial applications may require somewhat less time. Accordingly, for purposes of analysis, each benefits-sharing agreement's deferred payments (if any) were assumed to begin on average in the seventh year after execution of a benefits-sharing agreement.

As established in the model CRADA (*see* Appendix A), any obligation to make performance-based payments would survive termination of the agreement.[8] However, a practical estimate of the effective length of time when performance-based payments could occur is considered to be as long as the life of a U.S. patent, because the most common way to obtain legal protection for inventions is through patenting. U.S. patents are normally issued for a period of 20 years, within which only the inventor (and/or assignee) is authorized to make use of the invention. Accordingly, for purposes of analysis, each benefits-sharing agreement that paid deferred monetary benefits was also assumed to continue to do so for 20 years.[9]

If implemented, benefits-sharing would involve increasing numbers of agreements every year. As the years pass, more agreements each year might generate deferred benefits, as illustrated in Figure C.3.2.

C.4 License Income Reported by Federal and Academic Research Institutions

Estimates of the potential amount of monetary benefits are based on license income reported by federal and academic research institutions. In general, federal and academic institutions do not themselves commercialize research results. Usually, intermediate research results (the intellectual property of the researcher and his or her institution) are licensed to another institution for further R&D and eventual commercialization (*see* Chapter 1, Section 1.6).

Federal laboratories and academic institutions report their annual total license income as well as the royalties that contributed to the total income generated by licenses.[10] Royalty income from licensing is related to performance—a licensee must make money before it owes royalties.

For purposes of analysis in this DEIS, the reported royalty income from licensing was used to represent all performance-based payments to academic and federal institutions from licensing of research results.[11] Both federal laboratories and academic institutions report that royalties provide a substantial proportion of license income (*see* Tables C.10.2-1 *and* C.10.3-1).

In this DEIS, total license income received by an institution relative to research results, minus royalty income from licensing, is termed "other license income."[12] Possible components of other license income include, for example, up-front fees, annual minimum payments, and milestone payments. "Other license income" is not necessarily based on research results that have been completely developed and marketed; a license could yield "other license income" during the immediate benefits period of a benefits-sharing agreement.

Research projects are not always successful in producing a valuable new product or technology. The best available information for anticipating the proportion of benefits-sharing agreements that might generate payments to the NPS is discussed below. In addition, unavailable information, when known to the NPS, is described as required under NEPA.[13]

C.4.1 Best Available Information

AUTM provides the best information known to the NPS about income generated by commercial use of a wide range of research results over time. From 1999–2002, 43% of licenses reported by AUTM yielded income, and 23% yielded royalties (*see* Tables C.4.1-1 *and* C.4.1-2). Although the proportion of NPS benefits-sharing agreements that could generate income might be higher or lower than the AUTM average, analysis of potential impacts in this DEIS used these proportions for modeling potential monetary benefits.

Table C.4.1-1. Proportion of AUTM licenses that yielded income[14]

Year	FY1999	FY2000	FY2001	FY2002	Total licenses/years
Number of active licenses	18,617	20,968	22,937	26,086	88,608
Number of licenses yielding income	8,308	9,059	9,707	10,866	37,940
Percentages of active licenses yielding income = number of income-yielding licenses divided by the number of active licenses	45%	43%	42%	42%	43%

Table C.4.3-1. On average, 43% of AUTM licenses yielded income each year.

Table C.4.1-2. Proportion of AUTM licenses that yielded royalties[15]

	FY1999	FY2000	FY2001	FY2002	Total licenses/years
Number of active licenses	18,617	20,968	22,937	26,086	88,608
Number of licenses that yielded royalties = number of licenses multiplied by the percent of licenses that paid royalties	4,654	5,242	5,046	5,739	20,681
Percentage of active licenses that paid royalties	25%	25%	22%	22%	23% (Average—total active license/years divided by total royalty-yielding license/years)

Table C.4.3-2. On average, 23% of AUTM licenses yielded royalties each year.

C.4.2 Unavailable Information

The NPS does not have agency- or Department of the Interior-specific data with which to project the proportion of benefits-sharing agreements that could be likely to generate performance-based payments.[16] The only NPS-specific example of a benefits-sharing agreement is the Yellowstone–Diversa CRADA, under which a performance-based payment would be realized (for Pyrolase 200™; *see* Chapter 1, Section 1.2.4). No other NPS-specific data about the proportion of benefits-sharing agreements that could generate performance-based payments exists, because the NPS has not negotiated or entered into any additional benefits-sharing agreements.

Some limited information is available from federal laboratories about the number of licenses under which a research result becomes available for consumer or commercial use. For example, approximately 4% of the licenses held by the Department of Health and Human Services in 1999 and 2000 resulted in a research result becoming available for consumer or commercial use in those years. However, in making this report, the DOC explained that attributing year-specific cause and effect between licensing and consumer availability cannot be done, because "[d]ue to the inevitable time lags and activities by outside parties involved, there is normally no relationship between the level of activities [licensing] in a given FY [fiscal year] and the number of 'outcomes' [availability for consumer or commercial use] that can be itemized."[17]

C.5 Research Result Income Received by Commercial Firms

C.5.1 Best Available Information

Market data for industrial sectors that engage in natural products research, including pharmaceuticals, agricultural crop protection, soil remediation, industrial enzymes (detergents, starch, textiles, baking, beverages, dairy), biocatalysts, and diagnostics, are presented in Section C.8.3.1.

C.5.2 Unavailable Information

Information about income related to commercial use of research results by commercial firms is generally considered to be proprietary, and cannot be obtained to inform the analysis in this DEIS. The best information about the proportion of commercially related research projects that could ultimately could trigger performance-based payments is similarly proprietary, and unavailable for analysis.

C.6 CRADA Income Received by Federal Agencies

C.6.1 Best Available Information

None (*see* Section C.6.2).

C.6.2 Unavailable Information

There is no available information about funding of research under existing CRADAs, because the DOC does not collect or report such data.[18]

C.7 Potential Number of Agreements that Could Be Active Annually in the NPS

The estimate of the range of total annual monetary benefits that could be generated if Alternative B is implemented is based on potential average monetary benefits per agreement, multiplied by the number of benefits-sharing agreements that could generate such payments each year. For purposes of analysis, the number of benefits-sharing agreements that could be active each year is estimated at three benchmark levels: entering into two, four, or nine new agreements per year. These benchmarks were selected for analysis based on the number of inventions that might have been discovered related to the study of specimens originating in the NPS (*see* Section C.7.2).[19] The estimated number of inventions is based on the number of patents known to have been granted related to the study of specimens originating in the NPS (*see* Section C.7.1). The number of potential benefits-sharing agreements that could accumulate over the 20-year analysis period is estimated for each of the three benchmarks (*see* Section C.7.3).

C.7.1 NPS-related Patents

It is possible that on average, two benefits-sharing agreements could be established annually, which is consistent with the rate at which patents were granted for research results related to the study of specimens originally collected from NPS units during the 1994–2003 period (*see* Table C.7.1 *and* Chapter 1, Section 1.2.4).

Table C.7.1. NPS-related patents granted annually

Grant year	No. of patents	Grant year	No. of patents
1978	1	1991	0
1979	0	1992	3
1980	0	1993	1
1981	2	1994	4
1982	2	1995	1
1983	2	1996	3
1984	0	1997	0
1985	0	1998	5
1986	4	1999	6
1987	1	2000	3
1988	2	2001	0
1989	2	2002	1
1990	1	2003	1

Total patents granted: 45

Average per year: 2

Average per year, most recent decade (1994–2003): 2

Table C.7.1. An average of two patents related to study of NPS specimens are known to have been granted each year.

C.7.2 Potential Number of NPS-related Inventions

A benefits-sharing agreement could be based on an invention or other commercial application that was not patented (*see* the definition of "commercial purpose" in Appendix A). This DEIS estimates the possible number of inventions resulting from research involving NPS research specimens that could have occurred in the past by examining the comparative rates of patenting and inventing in other institutions. Under Alternative B, each invention could trigger a benefits-sharing agreement.

Federal laboratories and academic institutions report the number of inventions as well as patents made annually by researchers in their institutions. In every year, more inventions are recorded than patent applications filed, and more patent applications are filed than patents granted. This is because patent applications are not filed on every new invention, and not all inventions that are the subject of patent applications satisfy the statutory standards for patentability. However, each invention, whether patented or not, represents a potential commercial application for research results (*see* Chapter 1, Figures 1.9.1-3 *and* 1.9.2-2).

C.7.2.1 Best available information

Table C.7.2-1, below, shows the comparative rate of patenting and inventing by federal laboratories and academic institutions, with special emphasis on two federal departments: the Department of the Interior (DOI) and the Department of Health and Human Services (HHS). The DOI was examined separately—not only because it is the NPS's Departmental affiliate, but also because the relatively few patents and inventions reported by the DOI are managed by agencies that are, like the NPS, concerned with natural resources: the U.S. Geological Survey and the Bureau of Reclamation.[20] HHS was examined separately because the majority of its reported patents and inventions are generated by the National Institutes of Health (NIH) and, like the research expected to be most likely to trigger a benefits-sharing agreement, are related to biological research.[21] Data supporting Table C.7.2-1 are shown in Section C.10.1.

Table C.7.2-1. Comparative rates of inventing and patenting in federal laboratories and academic institutions

	DOI 1999–2001*	HHS 1999–2003	Federal laboratories, 1999–2003	AUTM, 1999–2002	Combined federal and AUTM data
Inventions	30	2,040	19,660	54,498	74,158
Patents	7	683	7,604	14,819	22,423
Comparative rate (CR) = Inventions (I) / Patents (P), or X times as many inventions as patents	4.3	3.0	2.6	3.7	3.3

**DOI did not report invention or patent numbers for 2002–2003.*

Table C.7.2-1. Federal laboratories and academic institutions report from 2.6 to 4.3 times as many inventions each year as patents.

Federal laboratories and academic institutions report from 2.6 to 4.3 times as many inventions each year as patents (*see* Table C.7.2-1). For purposes of analysis, these comparative rates were used to estimate the number of inventions that could have been generated by NPS-related research each year.

C.7.2.2 Estimating potential NPS-related inventions

The average number of patents known to have been granted each year relating to research involving NPS biological material was approximately two (*see* Table C.7.2-2). If the range of comparative rates of inventing to patenting (2.6 to 4.3) is calculated according to this average, then the annual number of inventions would have been between five and nine.

Table C.7.2-2. Estimated annual number of NPS-related inventions

	DOI rate	HHS rate	Federal laboratories rate	AUTM rate	Average rate
Average number of patents per year	2	2	2	2	2
Comparative rate of inventing and patenting	4.3	3.0	2.6	3.7	3.3
Estimated number of inventions per year	8.6	6.0	5.2	7.4	6.6

Table C.7.2-2. Research involving the study of biological material originally collected from a national park is estimated to generate an average of seven inventions annually.

In addition, multiple discoveries, inventions, or patents could be made by a single researcher. However, this DEIS seeks primarily to characterize potential impacts of the alternatives, rather than to estimate the potential number of patents, inventions, or other commercial applications that would trigger a benefits-sharing agreement. In particular, any monetary benefits (income) resulting from an NPS benefits-sharing program would be related more to the number of commercially valuable discoveries than strictly to the number of benefits-sharing agreements. This is because multiple valuable discoveries could be subject to a single agreement (*see* Chapter 1, Section 1.2.4).

C.7.3 Estimated Number of NPS Benefits-Sharing Agreements

The estimate of the range of total annual monetary benefits that could be generated under Alternative B is based on potential average monetary benefits per agreement, multiplied by the number of benefits-sharing agreements that could generate such payments each year. Three benchmark levels for the number of new agreements executed each year were used to develop the range of potential monetary benefits described in Section C.9 and used in

Chapter 4's impact analysis.

Any obligation to provide monetary benefits during the immediate benefits period is estimated in this DEIS to occur for an average period of five years (*see* Section C.3.1). Accordingly, by the fifth year after adoption of Alternative B, the number of agreements that could affect natural resource management by generating payments during their immediate benefits period would likely remain steady.

Any obligation to make performance-based payments would survive termination of the agreement (*see* Appendix A). Accordingly, implementation of benefits-sharing would involve increasing numbers of agreements every year. As the years pass, more agreements each year might generate deferred benefits, as illustrated visually in figure C.3.2, and in numerical detail in Table C.7.3.

Table C.7.3. Number of agreements that could generate benefits

	2 new agreements annually		4 new agreements annually		9 new agreements annually	
	Immediate benefits obligated	Deferred benefits obligated	Immediate benefits obligated	Deferred benefits obligated	Immediate benefits obligated	Deferred benefits obligated
Year 1	2	0	4	0	9	0
Year 2	4	0	8	0	18	0
Year 3	6	0	12	0	27	0
Year 4	8	0	16	0	36	0
Year 5	10	0	20	0	45	0
Year 6	10	0	20	0	45	0
Year 7	10	2	20	4	45	9
Year 8	10	4	20	8	45	18
Year 9	10	6	20	12	45	27
Year 10	10	8	20	16	45	36
Year 11	10	10	20	20	45	45
Year 12	10	12	20	24	45	54
Year 13	10	14	20	28	45	63
Year 14	10	16	20	32	45	72
Year 15	10	18	20	36	45	81
Year 16	10	20	20	40	45	90
Year 17	10	22	20	44	45	99
Year 18	10	24	20	48	45	108
Year 19	10	26	20	52	45	117
Year 20	10	28	20	56	45	126

Table C.7.3. A steady number of agreements could obligate monetary benefits after Year 5 of the immediate benefits period, while increasing numbers of agreements could obligate monetary benefits starting in Year 7 of the deferred benefits period.

C.8 Modeling Potential Monetary Benefits

Quantitative estimates of the potential monetary benefits to the NPS resulting from benefits-sharing were developed using two different models describing income generation, each of which could apply to some benefits-sharing agreements. These estimates vary widely, in large part because given the wide variety of processes, products, and services that could be developed, the profitability of each individual commercial application may vary widely (*see* Chapter 1, Section 1.2.4). Model One suggests a higher level of monetary benefits than Model Two; both account for a wide variation in possible monetary benefits. The potential number of benefits-sharing agreements that could be active each year was estimated in Section C.7.3. These preliminary estimates were combined to provide a range of potential estimated monetary benefits each year after implementation of Alternative B for purposes of evaluating potential quantitative impacts to natural resource management.

In addition to the wide variety of possible end products, the effort required to bring products to market varies widely. The development and regulatory approval processes are relatively short for chemical and industrial products, of intermediate length for agricultural products, and longer for pharmaceutical products. Accordingly, the amount of investment and effort needed to develop different types of products in different industrial sectors can affect the range of potential royalty rates or other performance-based payments that the NPS could reasonably expect to be generated by benefits-sharing agreements.

This section describes the models used for analysis and the estimated range of average payments that could accrue to the NPS under each model. Section C.10 contains data used in analysis and shows how these data led to the conclusions presented in Section C.9.

C.8.1 Model One (Researcher's Institution Completes All Stages of Bioprospecting)

In Model One, a researcher affiliated with an institution that could complete R&D of a commercially valuable research result; produce a product or perform a research-related service; and offer the final result for sale, lease, license, or other transfer for value would enter into a benefits-sharing agreement with the NPS. Model One assumes that all benefits-sharing agreements would generate some income, and that payments to the NPS could be roughly similar to payments made to academic institutions through licensing of research results.

Because Model One assumes that all benefits-sharing agreements would generate some income for the NPS, potential monetary benefits under Model One are calculated based only on income generated by licenses that yield income. Licenses that yield no income were excluded from this analysis.

C.8.1.1 Best available information

Model One is based solely on publicly available license income information collected and reported by AUTM (for academic institutions), because AUTM reports both license income and the proportion of licenses that yield income, and so the average payment per income-yielding and royalty-yielding licenses can be calculated.

The NPS is aware that the AUTM data reflect diverse variables such as the types of technologies under license, the types of licenses, the value of various technologies, and other factors. However, it is the best available information about the average income per license related to commercial use of research results known to the NPS.

C.8.1.2 Unavailable information

Because the information reported for federal laboratory license income does not identify the proportion of licenses that generate income, it cannot be used for Model One.

C.8.1.3 Immediate monetary benefits

Model One assumes that potential immediate monetary benefits would consist of up-front payments equivalent to average "other license income" (meaning total license income minus royalty income from licensing as reported by AUTM for licenses that yield income). Although individual payments would likely be higher or lower than the average, Model One suggests that potential annual payments averaging approximately $24,000 could accrue annually for an average period of five years, and would be part of the immediate benefits package associated with all benefits-sharing agreements. (Relevant data and calculations are presented in Section C.10.2.)

The NPS experience with immediate benefits negotiated under the Yellowstone–Diversa CRADA is consistent with this analysis, because under that CRADA, Diversa agreed to provide $20,000 annually to support Yellowstone's research activities consistent with the park's mission.

Model One estimates that the proportion of benefits-sharing agreements that could potentially generate immediate monetary benefits is 100%.

C.8.1.4 Deferred monetary benefits

For purposes of analysis in this DEIS, the estimated range of deferred monetary benefits, if any, under Model One was based on the average royalties received by academic institutions (AUTM) when royalties were generated. Although agreement-specific, performance-based payments would likely be higher or lower than the AUTM average, Model One suggests that potential payments averaging approximately $155,000 could accrue annually beginning in the seventh year after an agreement was established. (Relevant data and calculations are presented in Section C.10.3.)

Model One estimates the proportion of benefits-sharing agreements that could potentially generate deferred monetary benefits to be 23% (consistent with the proportion of AUTM licenses that generate royalties).

C.8.1.5 Model One monetary benefits summary

Table C.8.1.5. presents the benefits levels projected to occur under Model One (Researcher's Institution Completes All Stages of Bioprospecting).

Table C.8.1.5. Analysis of potential annual benefits per average benefits-sharing agreement based on data reported by AUTM (Model One)*

Benefit timing	Potential non-monetary benefits**	Potential monetary benefits
Immediate (5-year period)	Probable obligation to provide knowledge and research relationships, training or education, research-related equipment, or special services.	Average of $24,000 annually. All agreements would generate up-front payments.
Deferred (occurring after the end of the immediate benefits period)	Possible continuation of some or all non-monetary benefits.	Average of $155,000 on 23% of all agreements annually, beginning on average in the seventh year after each agreement is established (overall average of $36,000).

**Researcher's Institution Completes All Stages of Bioprospecting*

***See Chapter 4 for a full description of potential non-monetary benefits*

Table C.8.1.5. The average benefits-sharing agreement in Model One would include both non-monetary and monetary benefits.

C.8.2 Model Two (Researcher's Institution Develops Intellectual Property with Potential Commercial Uses)

In Model Two, a researcher affiliated with an institution that licensed, or otherwise transferred for value, its intermediate research results to another institution for continuation into later R&D stages, such as product development, manufacturing, and marketing, would enter into a benefits-sharing agreement with the NPS. Model Two assumes that both immediate and deferred monetary payments would consist of performance-based payments related directly to the amounts and patterns of income (if any) received by the researcher's institution from licensing intellectual property.

C.8.2.1 Best available information

Model Two is based on average license income generated by both academic and federal licenses. Estimated potential monetary benefits during the immediate benefits period are based on "other license income," and estimates for the deferred benefits period are based on royalty income (*see* Sections C.3.1 *and* C.3.2). Not all licenses generate income, and payments in Model Two would be part of only some of the benefits packages associated with benefits-sharing agreements: those for which the researcher's institution received income through licensing.

Model Two assumes that a researcher's institution could pay the NPS a portion of its income from licensing of research results. For purposes of analysis, an average performance-based payment rate of 3% was used to represent the proportion of its license income that a researcher's institution might obligate to the NPS under a benefits-sharing agreement. The average of the range of royalty rates reported in 1999 by ten Kate in *The Commercial Use of Biodiversity* for benefits-sharing agreements that related to raw samples or research specimens provided during the early stages of research was 3%.[22] Similarly, a study of the pharmaceutical industry reported that when an outside source provided research specimens during the early stages of research, royalty rates ranged between 1% and 5%.[23] Therefore,

potential immediate monetary benefits and potential deferred benefits were calculated at 3% of other license income and royalty license income received by the researcher's institution.

Estimates of monetary benefits in Model Two are based on income generated by AUTM licenses for 1999–2002, and by federal laboratory licenses for 1999–2003 (*see* Tables C.10.2-1 *and* C.10.3-1). This is the best information about income generated by commercial use of a wide range of research results over time known to the NPS.

C.8.2.2 Unavailable information

The average amount of revenue generated solely by income-yielding licenses is not known, because the DOC does not report that average. However, because not all licenses generate income, the all-license average income used for Model Two is necessarily lower than the average generated solely by income-yielding licenses.

Exact royalty rates related to bioprospecting research and paid to the entity that provided the research specimens are ordinarily proprietary and unavailable for analysis.

C.8.2.3 Immediate monetary benefits

Model Two estimates potential immediate monetary benefits as 3% of other license income received by researcher's institutions as reported by both AUTM and federal laboratories (meaning total license income minus royalty income from licensing as reported by AUTM and DOC for all licenses, whether or not they generate income). This all-license average (including both income-yielding and non-income-yielding agreements) is $300 per benefits-sharing agreement (*see* Section C.10.3). For purposes of analysis in this DEIS, these annual payments are assumed to occur for a period of five years for each benefits-sharing agreement. (Relevant data and calculations are presented in Section C.10.)

Model Two estimates the proportion of benefits-sharing agreements that could potentially generate immediate monetary benefits to be 43%.

C.8.2.4 Deferred monetary benefits

Model Two estimates potential deferred monetary benefits to be 3% of average royalty income received by researcher's institutions as reported by both AUTM and federal laboratories. Model Two suggests that potential annual payments averaging $900 could accrue annually beginning in the seventh year after an agreement was established. (Relevant data and calculations are presented in Section C.10.)

Model Two estimates the proportion of benefits-sharing agreements that could potentially generate deferred monetary benefits to be 23% (consistent with the proportion of AUTM licenses that generate royalties).

C.8.2.5 Model Two monetary benefits summary

Table C.8.2.5 presents the benefits levels projected to occur under Model Two (Researcher's Institution Develops Intellectual Property with Potential Commercial Uses).

Table C.8.2.5. Analysis of potential annual benefits per benefits-sharing agreement based on data reported by federal laboratories and AUTM (Model Two)*

Benefit timing	Potential non-monetary benefits**	Potential monetary benefits
Immediate (5-year period)	Probable obligation to provide knowledge and research relationships, training or education, research-related equipment, or special services.	Average of $300 annually.
Deferred (occurring after the end of the immediate benefits period)	Possible continuation of some or all non-monetary benefits.	Average of $900 annually, beginning on average in the seventh year after each agreement is established.

**Researcher's Institution Develops Intellectual Property with Potential Commercial Uses*
***Potential non-monetary benefits are described in detail in Chapter 4.*

Table C.8.2.5. The average benefits-sharing agreement in Model Two would include both non-monetary and monetary benefits.

C.8.3 Potential for High-Value Royalties

The likelihood that a high-value, performance-based payment (defined as more than $1 million annually) might result under Alternative B is analyzed here. Information is presented about markets in industrial sectors that engage in natural products research, license income data reported by federal laboratories and academic institutions, and income from the development of Taq polymerase.

Although markets indicate that the demand for research-related products is significant and growing, the likelihood of any particular research project resulting in a high-value product is very low. Federal and academic license income also indicates that royalty incomes of more than $1 million annually occur at a low rate (*see* Table C.8.3.2). There is only one known case in which development of research results involving study of an NPS research specimen has generated millions of dollars in annual income.

Chapter 4's impact analysis includes a possibility that Alternative B could generate income of more than $1 million annually. However, the number of NPS benefits-sharing agreements that might generate high-value royalties, if any, would likely be very low.

C.8.3.1 Market estimates

The high value of some of the most successful products resulting from biological research activities represent the high-end range of potential values resulting from biological research.

Some efforts to forecast the potential value of biological research results have been based on studies of the size of markets in industrial sectors that engage in natural products research. These industrial sectors include pharmaceuticals, agricultural crop protection, soil remediation, industrial enzymes (detergents, starch, textiles, baking, beverages, dairy), biocatalysts, and diagnostics.

Published estimates of the global markets for these industrial sectors indicate that they are robust and expanding. However, while these estimates indicate that the demand for and value

of such biological research results is substantial, the limited predictive value of such studies has been noted.[24] Thus, the following figures cannot be used to predict the potential value of any particular research result in any given field, and the demand for such research-related products varies widely between the total estimated value of pharmaceuticals compared with other sectors.

The potential value of biological research results is sometimes estimated from the value of particular products resulting from such research. However, as with total market estimates, these figures provide only limited estimates, and vary widely both within and among various industrial sectors. For example, 1997 revenue figures for only the top six pharmaceutical products with natural origins ranged from $941 million to $3.56 billion.[33] These figures represented significant increases over the revenue figures reported in 1990 for the top four pharmaceuticals with natural origins, which ranged from $665 million to $837 million.[34] In the agricultural crop protection sector, annual revenues for certain specific products derived from genetic resources have been reported to range from $100 million to $1.2 billion.[35]

Table C.8.3.1. Global markets

Industrial sector	Estimated market value (U.S. dollars)[25]
Pharmaceuticals	$300 billion[26]
Agricultural crop protection	$30 billion[27]
Soil remediation	$10–25 billion[28]
Industrial enzymes[29]	
Detergents	$0.7 billion
Starch	$0.16 billion
Textiles	$0.13 billion
Baking	$0.09 billion
Beverages	$0.09 billion
Dairy	$0.06 billion
Other[30]	$0.24 billion
Biocatalysts	$0.02–0.1 billion[31]
Diagnostics	$0.15–0.2 billion[32]

Table C.8.3.1. Estimated market values in industrial sectors that engage in natural products research activities range from $20 million to $300 billion.

C.8.3.2 Federal and academic licensing

The low probability of potential high-value royalty payments related to the commercial development of research results is illustrated by the license income data reported by federal laboratories and academic institutions.

The Department of Commerce reports that "earned royalty income" in FY2003 differed widely across federal agencies—from a license that yielded three dollars in FY2003 to one yielding $1.5 million.[36] Median earned royalty income for the four agencies that reported such information ranged from a low of $700 to a high of $10,000 annually (*see* Table C.8.3.2, below).[37]

Income greater than $1 million was reported by AUTM to occur for 0.6% of all licenses from 2000 through 2002. The potential for large license royalty payments also increased as an institution's license program aged. In 2001, AUTM reported that no technology transfer programs less than 11 years old generated more than $1 million annually in license income from all licenses held by a single institution.[38]

Based on the data reported by the Department of Commerce and AUTM, licenses that generate income of more than $1 million annually occur at a low rate, representing no more than 0.6% of licenses.

Table C.8.3.2. Federal and academic license income greater than $1 million[39]

Department	License/years (1 license active in 1 year = 1 license/year)	License/years yielding more than $1 million
Defense 2001[40]	288	1 (0.3%)
Energy 2001–2003[41]	9,151	≤ 2 (≤ 0.02%)
Agriculture 2001–2003, Commerce 2001–2003, Interior 2001, NASA 1999–2003, Transportation 1999–2003, Veterans Administration 2001	2,868	0 (0%)
Environmental Protection Agency and Health and Human Services, 1999–2003, Agriculture and Commerce 1999–2000, Interior 1999–2000, Veterans Administration 2002–2003	7,866	not reported
AUTM, 2000–2002	69,991	401 (0.6%)

Table C.8.3.2. Less than one percent of licenses reported recently by federal laboratories and academic institutions generated royalty payments of more than $1 million.

C.8.3.3 Taq polymerase

The most valuable product known to have resulted from research involving NPS research specimens was the Polymerase Chain Reaction (PCR), which involved the sale of patent rights estimated at $300 million, with an additional estimated $100 million in annual revenues for each of many years (*see* Chapter 1, Section 1.2.4).[42] The development of Taq polymerase is the only known development of research results involving study of an NPS research specimen that generated annual income of millions of dollars.

If research involving NPS research specimens resulted in another product with income equivalent to that reported for PCR, and if that product generated income for the NPS at a royalty rate of only 1%, the annual performance-based payment (royalty) to the NPS would be $1 million. A higher royalty rate would generate correspondingly more income for the NPS.[43]

C.8.3.4 Conclusion

In conclusion, the rate at which high-value royalties could be generated by NPS benefits-sharing agreements would likely be very low. To provide the full range of income estimates for analysis of the potential impacts of benefits-sharing agreements on parks, the possibility of generating royalties of more than $1 million annually was included in Chapter 4's impact analysis for 0.6% of agreements.

C.8.4 Modeling a Single Agreement

Individual parks other than Yellowstone could also negotiate and enter into benefits-sharing agreements. The historical record suggests that parks other than Yellowstone could be more likely to negotiate a single agreement than multiple agreements, because of the low numbers of bioprospectors working in NPS units other than Yellowstone. In 2001, although seven of the 12 research projects involving declared bioprospectors were conducted in NPS units other than Yellowstone, no park other than Yellowstone was host to more than one declared bioprospector. In addition, only two of the 45 known patents related to research involving NPS biological material did not involve material that originated in Yellowstone. For these reasons, and the fact that the effects of benefits-sharing would likely be most notable at the park level, this DEIS examined the potential impact of benefits that could be generated by a single agreement.

Actual annual income generated by a single license in both federal laboratories and academic institutions ranged from $0 to more than $1 million in recent years (*see* Tables C.4.1-1, C.8.3.2, *and* C.10.3.1). The following discussion uses Models One and Two to characterize potential monetary benefits of a single agreement in more detail.

C.8.4.1 Model One and a single agreement

The conclusions of Model One are presented in Section C.8.1. Because Model One assumes that all benefits-sharing agreements would generate some income, these conclusions could apply to parks with a single agreement.

C.8.4.2 Model Two and a single agreement

Model Two assumes that not all agreements would generate income. However, the conclusions presented for Model Two in Section C.8.2 were expressed as averages for all benefits-sharing agreements, including agreements without income. Accordingly, further interpretation is needed to characterize the potential monetary benefits of any single agreement under Model Two.

Figure C.8.4.1.
Proportion of Model One Agreements Estimated to Generate Income

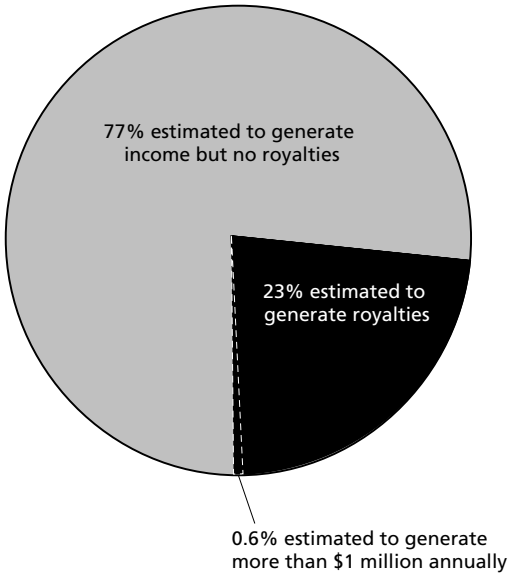

Figure C.8.4.1. Model One estimates that every benefits-sharing agreement could generate some income.

Figure C.8.4.2.
Proportion of Academic Annual License Income Levels

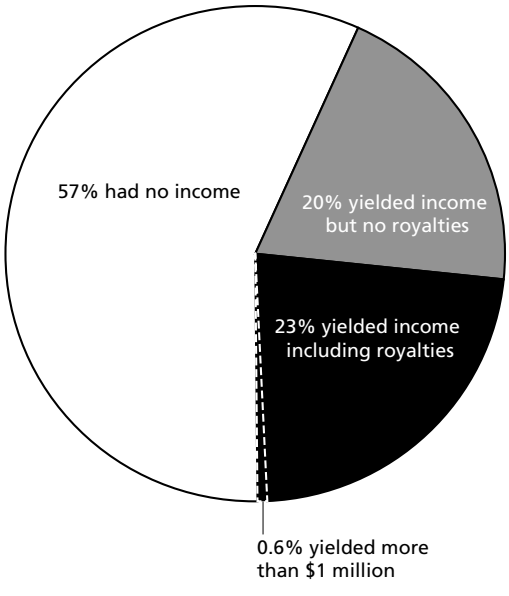

Figure C.8.4.2. Annual licensing income at academic institutions ranged from $0 for more than half of all licenses to more than $1 million for 0.6% of licenses in 1999–2002.

Potential monetary benefits in Model Two could be realized at similar frequencies to those reported by AUTM. From 1999–2002, AUTM reported that 57% of licenses generated no income, 20% yielded income but no royalties, and 23% generated royalty income as illustrated in Figure C.8.4.2.

Model Two's estimated average annual monetary benefits were calculated per active agreement. However, only 43% of agreements would be likely to generate monetary benefits. An estimate of the average monetary benefits generated by a single, income-generating Model Two agreement is shown in Table C.8.4.2.

Table C.8.4.2. Estimated potential average annual monetary benefits of Model Two applied to a single agreement

If immediate benefits period payments for all Model Two agreements average $300 annually, but only 43% of agreements generate those payments, what might a single income-generating agreement average annually during the immediate benefits period?	$700
If deferred benefits period payments for all Model Two agreements average $900 annually, but only 23% of agreements generate those payments, what might a single income-generating agreement average annually during the deferred benefits period?	$4,000

Table C.8.4.2. Under Model Two, a benefits-sharing agreement is estimated to generate approximately $700 when immediate benefits occur (43% of agreements) and approximately $4,000 when deferred benefits occur (23% of agreements).

C.8.5 Fitting the Models Together: Preparing to Estimate the Range of Potential Monetary Benefits

In this section, the proportion of agreements that could be more like Model One or Model Two is estimated.

The NPS expects that in general, commercial research firms could be more likely to complete all stages of bioprospecting (as described in Model One), and academic or federal institutions could be more likely to develop intellectual property that would be licensed to other institutions for further R&D (as described in Model Two). It is recognized that there are considerable variations from the norm described by these two models, and that the specific terms and conditions describing the benefits obligated by a benefits-sharing agreement would be negotiated individually in each case. The NPS is aware that commercial firms also license intermediate research results to other institutions.

The proportion of potential benefits-sharing agreements that could be entered into with either commercial research firms or academic institutions was characterized by examining the record of patents known to be related to the study of NPS research specimens. When a patent is granted, an "assignee" receives the rights associated with the patent. The rights to these patents were assigned to commercial firms, academic institutions, federal institutions, and non-U.S. institutions as shown in Table C.8.5.

Table C.8.5. Patents and assignees known to be related to study of NPS specimens, 1978–2003

	Number of patents	Number of assignees
U.S. commercial firms	16	11
U.S. government institutions	3	2
U.S. institutions fitting the description of AUTM members (whether or not actually included in AUTM surveys)	19	8
Non-U.S. institutions[44]	7	4
Total	**45**	**25**

Table C.8.5. The rights to patents related to study of NPS research specimens were assigned to a variety of institutions.

Because patents were assigned to 11 commercial firms (Model One) and 10 government and academic institutions, monetary benefits like those described in Models One or Two are estimated to occur at nearly equal frequencies for purposes of analysis in this DEIS.

C.9 Summary of Potential Monetary Benefits

This section provides an estimated range of potential monetary benefits in each context for this DEIS (servicewide, Yellowstone National Park, and individual parks) and summarizes how the estimates were developed. The estimated range of potential monetary benefits is used in Chapter 4 to analyze the quantitative impacts of Alternative B on natural resource management. Data and calculations for these estimates are in Section C.10, and the estimates are compared to impact thresholds in Section C.11.

The estimated average potential monetary benefits per benefits-sharing agreement (Table C.9) was based on the premise that Models One and Two could occur with equal frequency (*see* Section C.8.5). Immediate benefits were estimated to occur during the first five years of an agreement (*see* Section C.3.1). Deferred benefits were estimated to occur between the seventh and twentieth years of each agreement (*see* Section C.3.2).

Table C.9. Average monetary benefits per benefits-sharing agreement

	Model One	Model Two
Immediate benefits period accrued annually during years 1–5 of the agreement)	$24,000	$300
Deferred benefits period accrued annually during years 7–20 of the agreement)	$36,000	$900

C.9.1 Servicewide Context

To estimate potential monetary benefits, three benchmarks were established: two, four, or nine new benefits-sharing agreements per year (*see* Section C.7). Chapter 4, Section 4.2, defines a short-term impact as any change that is evident for five years or less. Accordingly, the summary of the range of potential monetary benefits shown in Table 9.1 displays potential benefits in years one and five of an NPS benefits-sharing program. Chapter 4, Section 4.2, defines a long-term impact as any change that is evident after 20 years. Accordingly, Table 9.1 also displays potential benefits of years 10 and 20. The calculations that underlie this summary are presented in Section C.10.

The table below, summarizing the range of potential monetary benefits, appeared in Chapter 4 as Table 4.4.1.3-1. It is repeated here as Table 9.1 for reference. The calculations that underlie this summary are presented in Section C.10.4.1-2.

C.9.2 Yellowstone National Park Context

Yellowstone National Park was selected for a park-specific analysis because the historical patent record suggests that multiple discoveries with commercial application could be based on research involving research material originating in Yellowstone (*see* Chapter 1, Section 1.2.4). For this reason, the potential impacts to Yellowstone were evaluated in the event that the majority of NPS benefits-sharing agreements were established between researchers and Yellowstone National Park.

Table 9.1, above, showing the range of potential monetary benefits servicewide, was also used to evaluate potential impacts in the Yellowstone context.

C.9.3 Other Individual Parks Context

Based on the foregoing discussion, the estimated range of potential monetary benefits of a single benefits-sharing agreement can be summarized as follows.

C.9.3.1 Immediate benefits period

Model One estimates an annual average immediate period payment of $24,000 for 100% of agreements. Because each agreement would have an equal chance to generate payments like Model One or like Model Two, 50% of agreements are estimated to generate an average $24,000 annual payment during the immediate benefits period.

Model One: 100% ÷ 2 = 50%

Model Two estimates an annual average payment of $700 when income is generated, but only 43% of agreements would generate immediate payments. Because 50% of agreements could be like Model Two, 21.5% (one half of 43%) of agreements are estimated to generate an average $700 annual payment during the immediate benefits period. The remaining agreements would generate no immediate payment, meaning that 28.5% of all agreements would likely generate no immediate payment.

Model Two (income-generating): 100% ÷ 2 = 50% × 43% = 21.5%
Model Two (non-income-generating): 100% ÷ 2 = 50% × 57% = 28.5%

C.9.3.2 Deferred benefits period

Because both Models One and Two estimate that only 23% of agreements would generate performance-based payments, 77% of agreements are estimated to generate no deferred monetary benefits ($0). Model One estimates an average deferred period payment of $155,000; because 50% of agreements could be like Model One, 11.5% of agreements are estimated to generate such a payment. Model Two estimates an average deferred payment of $4,000 for a single agreement; because 50% of agreements could be like Model Two, 11.5% of agreements are estimated to generate such a payment. In addition, the impact analysis in this DEIS includes the possibility of an annual payment of more than $1 million for an estimated 0.6% of agreements.

Chapter 4's impact analysis was based on rounded numbers as displayed in Table 4.4.1.2-2, below. The calculations that underlie this summary are presented in Section C.10.

Table 4.4.1.2-2. Estimated range of potential monetary benefits used to analyze the impacts of a proposed NPS benefits-sharing program on individual parks other than Yellowstone

Duration of potential impact	Potential annual payment	% of agreements likely to yield this average benefits level (*see* Appendix C, Section C.9.3)	See Appendix C (Sections referenced) for the derivation of this estimate
Short-term impact analysis	0	29%	Model Two (Section C.8.2)
	$700	22%	Model Two (Section C.8.2)
	$24,000	50%	Model One (Section C.8.1)
Long-term impact analysis	0	77%	Both models
	$4,000	12%	Model Two (Section C.8.2)
	$155,000	12%	Model One (Section C.8.1)
	$1,000,000	0.6%	High-value royalty analysis (Section C.8.3)

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C.10 Data and Calculations

Section C.10 provides the information assembled by the NPS and used for estimating potential monetary benefits. These estimates are the basis for the quantitative analysis of the impacts of Alternative B to NPS natural resource management in Chapter 4.

C.10.1 Comparative Rate of Patenting and Inventing (Calculations for Table C.7.2-1)

The following data and calculated sums and averages were used to develop Table C.7.2-1.

Table C.10.1. Calculations in support of Table C.7.2-1
(Comparative rate of inventing and patenting in federal laboratories and academic institutions)

Federal inventions and patents [DOC2004, page 24]							
	FY1999	**FY2000**	**FY2001**	**FY2002**	**FY2003**	**Total reported**	**Comparative rate***
DOI inventions	8	16	6	not reported	not reported	30	
DOI patents granted	1	4	2	not reported	not reported	7	4.3
HHS inventions	328	375	434	431	472	2,040	
HHS patents granted	180	132	119	116	136	683	3.0
All federal labs inventions	3,649	3,566	3,962	4,135	4,348	19,660	
All federal labs patents granted	1,450	1,444	1,605	1,498	1,607	7,604	2.6

AUTM inventions and patents [AUTM2002, pages 10 and 11]							
	FY1999	**FY2000**	**FY2001**	**FY2002**		**Total reported**	**Comparative rate***
Inventions disclosed	12,324	13,032	13,569	15,573		54,498	
Patents granted	3,661	3,764	3,721	3,673		14,819	3.7

Grand total inventions disclosed	**74,158**	
Grand total patents granted	**22,423**	**3.3**

**The comparative rate (CR) of patenting (P) to inventing (I) is shown as CR=I/P.*

C.10.2 Potential Monetary Benefits of Model One Described in Section C.8.1

Table C.10.2-1. Data reported by AUTM and used for development of Model One and Tables 10.2-2 and 10.2-3

Data reported by AUTM	Data reference [year of AUTM report/page #]	FY1999	FY2000	FY2001	FY2002
New licenses	[2002/page 15]	3,914	4,362	4,058	4,673
Active licenses	[2002/page 15]	18,617	20,968	22,937	26,086
Licenses that yield income	[2002/ page 18]	8,308	9,059	9,707	10,866
Total "net" income (definition 2002/page 18 = not including money paid to other institutions, thus avoiding double counting)	[2002/page 18]	$862,000,000	$1,263,000,000	$1,071,000,000	$1,267,000,000
Percent of active licenses that paid royalties or had product sales this year	[1999/page i; 2000/page 1; 2001/page 1; 2002/ page 1]	25%	25%	22%	22%
Royalties are X% of income	[1999/page 15; 2000/page 12: 2001/page 12: 2002/page 19]	83%	57%	74%	79%
Cashed-in equity is X% of income	[1999/page 15; 2000/page 12; 2001/page 12; 2002/page 19]	3%	13%	10%	2%

Table C.10.2-2. Calculations for Model One (estimated immediate monetary benefits)*

	FY1999	FY2000	FY2001	FY2002	Total
Other license income = net income minus royalty income minus income from cashed-in equity	$120,680,000	$378,900,000	$171,360,000	$240,730,000	$911,670,000
Licenses that yield income (number of income-yielding license/years, where 1 license/year equals 1 license active for 1 year)	8,308	9,059	9,707	10,866	37,940

Average annual other license income per income-yielding license = total other license income ($911,670,000) divided by the number of income-yielding license/ years (37,940)	$24,029
Model One average immediate monetary benefit used in this DEIS to estimate potential impacts of Alternative B	**$24,029 (rounded to $24,000)**

**Model One assumes that potential immediate monetary benefits would consist of up-front payments equivalent to average "other license income" (meaning total license income minus royalty income from licensing as reported by AUTM for licenses that yield income).*

Table C.10.2-3. Calculations for Model One (estimated deferred monetary benefits)*

	FY1999	FY2000	FY2001	FY2002	Total
Royalty income = net income multiplied by the percent of income that is from royalties	$715,460,000	$719,910,000	$792,540,000	$1,000,930,000	$3,228,840,000
Number of royalty-yielding licenses = number of active licenses multiplied by percent of active licenses yielding royalties	4,654	5,242	5,046	5,843	20,785
Average annual royalty payment per royalty-yielding license = royalty income divided by the number of royalty-yielding licenses	$153,722	$137,335	$157,059	$171,296	$155,345

Four-year average annual royalty payment per royalty-yielding license = total royalty income divided by total number of royalty-yielding license/years	$155,345
Model One average deferred monetary benefit for those agreements that generate deferred benefits	**$155,345 (rounded to $155,000)**
% of agreements that could generate deferred monetary benefits = the % of AUTM licenses that yield royalties	23%
Model One average deferred monetary benefit per benefits-sharing agreement is used in this DEIS to estimate potential impacts of Alternative B	**$35,729 (rounded to $36,000)**

**Model One assumes that deferred monetary benefits (if any) would be equivalent to average royalties received by academic institutions when royalties are generated.*

C.10.3. Potential Monetary Benefits of Model Two Described in Section C.8.2

Table C.10.3-1. Data reported by the Department of Commerce and used for development of Model Two and Tables 10.3-2 and 10.3-3

Data reported by DOC	Agency	Page # DOC2004 Report	FY1999	FY2000	FY2001	FY2002	FY2003
Data highlighted in grey was removed from analysis because earned royalty income or total income) was not reported.							
Active licenses	Agriculture	pages 30–32	218	225	255	267	270
	Commerce		43	43	40	41	101
	Defense		not reported	not reported	288	471	364
	Energy		1,922	2,070	2,005	3,459	3,687
	EPA		17	18	16	23	32
	HHS		1,364	1,608	1,367	1,357	1,380
	Interior		12	6	8	not reported	not reported
	NASA		288	305	328	357	521
	Transportation		0	0	1	0	0
	VA		not reported	not reported	86	81	88
		Totals	3,847	4,257	4,106	5,504	5,991
Total license income	Agriculture	page 37	$2,377,000	$2,555,000	$2,622,000	$2,571,378	$2,290,903
	Commerce		$405,469	$186,368	$268,568	$164,622	$127,566
	Defense		$2,005,000	$2,213,000	$6,465,468	$6,715,597	$9,965,586
	Energy		$11,764,000	$15,840,000	$21,403,362	$23,476,716	$25,805,498
	EPA		not reported	not reported	$544,431	$400,437	$907,604
	HHS		$44,821,000	$52,547,000	$46,722,000	$52,882,331	$55,198,722
	Interior		$1,640,000	$850,000	$235,000	not reported	not reported
	NASA		$1,360,061	$1,756,796	$1,970,739	$2,498,167	$2,852,985
	Transportation		$0	$0	$5,500	$0	$0
	VA		not reported	not reported	$38,000	$18,000	$153,000
		Totals	$62,367,530	$73,735,164	$73,809,600	$81,993,651	$87,183,278
Earned royalty income	Agriculture	page 37	$1,843,000	$1,843,000	$1,409,252	$1,569,877	$1,560,825
	Commerce		$405,279	$186,368	$263,568	$99,152	$127,566
	Defense		not reported	not reported	not reported	not reported	not reported
	Energy		$1,975,000	$2,228,000	$7,832,481	$5,604,774	$6,611,568
	EPA		not reported	$533,906	$315,000	$677,354	$0
	HHS		$34,599,000	$43,892,000	$36,612,000	$36,012,005	$38,338,328
	Interior		$1,640,000	$850,000	$220,000	not reported	not reported
	NASA		$183,294	$116,490	$521,164	$554,769	$814,624
	Transportation		$0	$0	not reported	$0	$0
	VA		not reported	not reported	$17,000	not reported	not reported
		Totals	**$40,645,573**	**$49,115,858**	**$47,190,465**	**$44,517,931**	**$47,452,911**

Table C.10.3-2. Calculations for Model Two (estimated immediate monetary benefits)*

	FY1999	FY2000	FY2001	FY2002	FY2003	Total
Other license income, federal component						
Total income for agencies that report both royalties and total income	$62,367,530	$73,735,164	$73,809,600	$81,993,651	$87,183,278	$379,089,223
Total earned royalty income	$40,645,573	$49,115,858	$47,190,465	$44,517,931	$47,452,911	$228,922,738
Other license income = total income minus royalty income	$21,721,957	$24,619,306	$26,619,135	$37,475,720	$39,730,367	$150,166,485
Other license income, AUTM component (see Table C.10.2-2)	$120,680,000	$378,900,000	$171,360,000	$240,730,000	N/A	$911,670,000
					Total	**$1,061,836,485**
Active licenses						
Federal laboratory active licenses for agencies that report both royalties and total income	3,847	4,257	4,106	5,504	5,991	23,705
AUTM active licenses [AUTM2002/page 15] (see Table 10.2-1)	18,617	20,968	22,937	26,086	N/A	88,608
					Total	**112,313**

All reported other license income, 1999–2003	$1,061,836,485
All reported license/years (where 1 license/year equals 1 license active for 1 year)	112,313
Average annual other license income per active license = all other license income divided by the number of license/years	$9,454
Average benefits related to annual other license income per active license	3% (.03)
Model Two average immediate monetary benefit used in this DEIS to estimate potential impacts of Alternative B	**$284 (rounded to $300)**

**Model Two estimates potential immediate monetary benefits as 3% of "other license income" received by researcher's institutions as reported by both AUTM and federal laboratories.*

Table C.10.3-3. Calculations for Model Two (estimated deferred monetary benefits)*

	FY1999	FY2000	FY2001	FY2002	FY2003	Total
Royalty income, federal component						
Sum of royalty income for agencies that report both royalties and total income	$40,645,573	$49,115,858	$47,190,465	$44,517,931	$47,452,911	$228,922,738
Royalty income, AUTM component						
Sum of royalty income (see Table 10.2-3)	$715,460,000	$719,910,000	$792,540,000	$1,000,930,000	N/A	$3,228,840,000
					Total	$3,457,762,738
Active licenses						
Federal laboratory active licenses for agencies that report both royalties and total income	3,847	4,257	4,106	5,504	5,991	23,705
AUTM active licenses [AUTM2002/page 15] (see Table 10.2-1)	18,617	20,968	22,937	26,086	N/A	88,608
					Total	112,313

All reported royalty income 1999–2003	$3,457,762,738
All reported license/years (where 1 license/year equals 1 license active for 1 year)	112,313
Average annual royalty per active license = all royalty income divided by the number of license/years	$30,787
Average benefits related to annual other license income per active license	3% (.03)
Model Two average deferred monetary benefit used in this DEIS to estimate potential impacts of Alternative B	**$924 (rounded to $900)**

**Model Two estimates potential deferred monetary benefits as 3% of average royalty income received by researcher's institutions as reported by both AUTM and federal laboratories.*

C.10.4. Estimating the Range of Total Annual Monetary Benefits That Could Be Generated Under Alternative B

The basis for calculation of the range of potential monetary payments that could be generated for the NPS under Alternative B is described by three benchmarks: two, four or nine new agreements per year (see Section C.7.3.).

The calculation also uses three potential income levels: Model One, Model Two, and a potential high-value royalty payment of more than $1 million annually. Models One and Two are included in these calculations at equal frequencies (see Section C.8.5).[45] Because of the potential low frequency of high value royalties (see Section C.8.2), they are included in analysis only within the nine new agreements per year benchmark.

Section C.10.4 provides the data and calculations used to develop the conclusions shown in Chapter 4, Table 4.4.1.3-1, and is repeated below for reference.

Table 4.4.1.2-1. Range of potential monetary benefits used to analyze the potential impacts of a proposed NPS benefits-sharing program: servicewide and Yellowstone contexts

	2 new agreements annually	4 new agreements annually	9 new agreements annually	9 new agreements and at least one $1 million performance-based payment annually
Year 1	$24,300	$48,600	$109,350	no royalties expected this year
Year 5	$121,500	$243,000	$546,750	no royalties expected this year
Year 10	$269,100	$538,200	$1,210,950	$2,210,950
Year 20	$638,100	$1,276,200	$2,871,450	$3,871,450

C.10.4.1. Estimating the Range of Potential Total Income That Could Be Generated Under Alternative B

The average estimated monetary benefits per agreement as developed in Sections C.8.1 and C.8.2 are displayed in Table C.10.4.1-1.

Table C.10.4.1-1. Estimated annual average monetary benefits per agreement

	Estimated average immediate annual monetary benefits per agreement	Estimated average deferred annual monetary benefits per agreement
Model One	$24,029 (rounded to $24,000)	$35,729 (rounded to $36,000)
Model Two	$284 (rounded to $300)	$924 (rounded to $900)

Table C.10.4.1-2. Calculating estimated potential monetary benefits

	Immediate monetary benefits			Deferred monetary benefits			
	Number of agreements that could yield immediate benefits*	Model One ($24,000 per agreement)	Model Two ($300 per agreement)	Number of agreements that could yield deferred benefits*	Model One ($36,000 per agreement)	Model Two ($900 per agreement)	Total
Low range, 2 new benefits-sharing agreements per year							
Year 1	2	$24,000 (1 agreement)	$300 (1 agreement)	0	$0	$0	$24,300
Year 5	10	$120,000 (5 agreements)	$1,500 (5 agreements)	0	$0	$0	$121,500
Year 10	10	$120,000	$1,500	8	$144,000 (4 agreements)	$3,600 (4 agreements)	$269,100
Year 20	10	$120,000	$1,500	28	$504,000 (14 agreements)	$12,600 (14 agreements)	$638,100
Mid-range, 4 new benefits-sharing agreements per year							
Year 1	4	$48,000 (2 agreements)	$600 (2 agreements)	0	$0	$0	$48,600
Year 5	20	$240,000 (10 agreements)	$3,000 (10 agreements)	0	$0	$0	$243,000
Year 10	20	$240,000	$3,000	16	$288,000 (8 agreements)	$7,200 (8 agreements)	$538,200
Year 20	20	$240,000	$3,000	56	$1,008,000 (28 agreements)	$25,200 (28 agreements)	$1,276,200
High range, 9 new benefits-sharing agreements per year							
Year 1	9	$108,000 (4.5 agreements)	$1,350 (4.5 agreements)	0	$0	$0	$109,350
Year 5	45	$540,000 (22.5 agreements)	$6,750 (22.5 agreements)	0	$0	$0	$546,750
Year 10	45	$540,000	$6,750	36	$648,000 (18 agreements)	$16,200 (18 agreements)	$1,210,950
Year 20	45	$540,000	$6,750	126	$2,268,000 (63 agreements)	$56,700 (63 agreements)	$2,871,450
High range plus an annual performance-based payment of at least $1 million							
Year 1							No royalties expected this year
Year 5							No royalties expected this year
Year 10							$2,210,950
Year 20							$3,871,450

**see Table C.7.3*

C.11. Comparing Estimated Monetary Benefits to Impact Thresholds

Table C.11-1. Comparison of potential SERVICEWIDE monetary benefits to FY2004 Natural Resource Challenge funding*

Impact definitions (*see* Chapter 4, Section 4.2)	
Major impact	15% of $72,963,000
Moderate impact	10% of $72,963,000
Minor impact	5% of $72,963,000
Negligible impact	less than 5% of $72,963,000

Impact determinations												
Year	Low range (2 new agreements)			Mid-range (4 new agreements)			High range (9 new agreements)			High range plus $1 million annually		
	Total benefits	Percent	Impact	Total benefits	Percent	Impact	Total benefits	Percent	Impact	Total benefits	Percent	Impact
1	$24,300	0.03%	Negligible	$48,600	0.07%	Negligible	$109,350	0.15%	Negligible			
5	$121,500	0.17%	Negligible	$243,000	0.33%	Negligible	$546,750	0.75%	Negligible			
10	$269,100	0.37%	Negligible	$538,200	0.74%	Negligible	$1,210,950	1.66%	Negligible	$2,210,950	3.03%	Negligible
20	$638,100	0.87%	Negligible	$1,276,200	1.74%	Negligible	$2,871,450	3.93%	Negligible	$3,871,450	5.30%	Minor

**CALCULATION: estimated monetary benefits (see Table 4.4.1.3-1) divided by $8,800,490*

Table C.11-2. Comparison of potential YELLOWSTONE NATIONAL PARK monetary benefits to Yellowstone's identified natural resource management funding level (see Chapter 3, Section 3.2.2)

Impact definitions (*see* Chapter 4, Section 4.2)	
Major impact	35% of $8,800,490 = $3,080,172
Moderate impact	20% of $8,800,490 = $1,760,098
Minor impact	10% of $8,800,490 = $880,049
Negligible impact	<10% of $8,800,490 = <$880,049

Impact determinations												
Year	Low range (2 new agreements)			Mid-range (4 new agreements)			High range (9 new agreements)			High range plus $1 million annually		
	Total benefits	Percent	Impact	Total benefits	Percent	Impact	Total benefits	Percent	Impact	Total benefits	Percent	Impact
1	$24,300	0.3%	Negligible	$48,600	0.6%	Negligible	$109,350	1.2%	Negligible			
5	$121,500	1.4%	Negligible	$243,000	2.8%	Negligible	$546,750	6.2%	Negligible			
10	$269,100	3.1%	Negligible	$538,200	6.1%	Negligible	$1,210,950	13.8%	Minor	$2,210,950	25.1%	Moderate
20	$638,100	7.3%	Negligible	$1,276,200	14.5%	Minor	$2,871,450	32.6%	Moderate	$3,871,450	44.0%	Major

**CALCULATION: estimated monetary benefits (see Table 4.4.1.3-1) divided by $8,800,490*

Table C.11-3. Comparison of potential INDIVIDUAL PARK monetary benefits to each park's natural resource management funding level

Park code	Natural resource management funding level	Potential monetary benefit increments used for impact analysis					
			Model Two		Model One		$1 million agreement
		0	$700 (immediate)	$4,000 (deferred)	$24,000 (immediate)	$155,000 (deferred)	$1,000,000
WHSA	$21,701	0%	3%	18%	111%	714%	4608%
TIMU	$54,783	0%	1%	7%	44%	283%	1825%
VICK	$55,524	0%	1%	7%	43%	279%	1801%
SAGA	$58,400	0%	1%	7%	41%	265%	1712%
VAFO	$91,536	0%	0.8%	4%	26%	169%	1092%
GETT	$120,020	0%	0.6%	3%	20%	129%	833%
NACC	$127,925	0%	0.5%	3%	19%	121%	782%
MORU	$133,387	0%	0.5%	3%	18%	116%	750%
BRCA	$170,163	0%	0.4%	2%	14%	91%	588%
ISRO	$184,571	0%	0.4%	2%	13%	84%	542%
APIS	$239,376	0%	0.3%	2%	10%	65%	418%
GUMO	$269,541	0%	0.3%	1%	9%	58%	371%
CHOH	$310,544	0%	0.2%	1%	8%	50%	322%
VIIS	$366,866	0%	0.2%	1%	7%	42%	273%
CAHA	$389,709	0%	0.2%	1%	6%	40%	257%
LACL	$415,024	0%	0.2%	1.0%	6%	37%	241%
GLCA	$416,763	0%	0.2%	1.0%	6%	37%	240%
SAMO	$454,922	0%	0.2%	0.9%	5%	34%	220%
KATM	$464,346	0%	0.2%	0.9%	5%	33%	215%
OZAR	$564,333	0%	0.1%	0.7%	4%	27%	177%
ACAD	$597,155	0%	0.1%	0.7%	4%	26%	167%
VOYA	$601,693	0%	0.1%	0.7%	4%	26%	166%
MORA	$603,166	0%	0.1%	0.7%	4%	26%	166%
JOTR	$627,336	0%	0.1%	0.6%	4%	25%	159%
BIBE	$650,623	0%	0.1%	0.6%	4%	24%	154%
LAVO	$798,816	0%	0.09%	0.5%	3%	19%	125%
BAND	$866,385	0%	0.08%	0.5%	3%	18%	115%
BADL	$872,988	0%	0.08%	0.5%	3%	18%	115%
INDU	$915,831	0%	0.08%	0.4%	3%	17%	109%
WRST	$1,013,200	0%	0.07%	0.4%	2%	15%	99%
CACO	$1,046,270	0%	0.07%	0.4%	2%	15%	96%
PORE	$1,134,550	0%	0.06%	0.4%	2%	14%	88%
LAME	$1,178,921	0%	0.06%	0.3%	2%	13%	85%
ZION	$1,313,382	0%	0.05%	0.3%	2%	12%	76%

Park code	Natural resource management funding level	Potential monetary benefit increments used for impact analysis					
			Model Two		Model One		$1 million agreement
		0	$700 (immediate)	$4,000 (deferred)	$24,000 (immediate)	$155,000 (deferred)	$1,000,000
ROMO	$1,556,210	0%	0.04%	0.3%	2%	10%	64%
GRTE	$1,616,934	0%	0.04%	0.2%	1%	10%	62%
DENA	$1,803,935	0%	0.04%	0.2%	1%	9%	55%
REDW	$1,954,456	0%	0.04%	0.2%	1%	8%	51%
SHEN	$2,172,881	0%	0.03%	0.2%	1%	7%	46%
OLYM	$3,673,140	0%	0.02%	0.1%	0.7%	4%	27%
GOGA	$5,050,202	0%	0.01%	0.08%	0.5%	3%	20%
GRCA	$5,385,078	0%	0.01%	0.07%	0.4%	3%	19%
EVER	$7,763,353	0%	0.01%	0.05%	0.3%	2%	13%

**CALCULATION: estimated monetary benefits (see Table C.9.3) divided by each park's natural resource management funding level*

Table C.11-4 summarizes the conclusions presented in Table C.11-3, above. It shows how many of the 43 parks selected for impact analysis would experience beneficial impacts at each monetary benefits level (benefits levels are shown according to immediate or deferred benefits periods). Impacts could range from no impact to a major beneficial impact during both the immediate and the deferred benefits periods. However, beneficial impacts would be negligible for the majority of parks studied at either the $700 or the $24,000 benefits levels during the immediate benefits period.

Table C.11-4. Number of study parks at each impact threshold (*n* = 43)

Impact level	No impact (no payments)	Negligible (less than 10%)	Minor (10%)	Moderate (20%)	Major (35%)
Immediate benefits period					
$0	43	-	-	-	-
$700	-	43	-	-	-
$24,000	-	32	5	2	4
Deferred benefits period					
$0	43	-	-	-	-
$4,000	-	42	1	-	-
$155,000	-	7	11	8	17
$1,000,000	-	3	1	1	38

Notes

Section C.1 Introduction

[1] Licenses allow another institution to use the intellectual property (the ideas and knowledge) that was protected in the second stage of a bioprospecting research project (*see* Chapter 3, Section 3.4.3 of this document).

[2] In the case of license income reported by academic institutions, income attributed to cashed-in equity was removed from analysis because the NPS does not expect to realize any similar income.

[3] In addition, an alternative estimate of the potential monetary benefits of Alternative B was based instead on a two-year dataset, FY2002–FY2003, from the AUTM 2003 report. This analysis is on file at Yellowstone National Park. Data from both the 2003 and 2002 AUTM reports were analyzed separately because AUTM revised its reporting criteria between those years, reporting on academic institutions in both the U.S. and Canada up to 2002, and restricting their report to U.S. institutions in 2003. The conclusions regarding potential quantitative impacts of Alternative B on NPS Natural Resource Management in Chapter 4 remain unchanged under this alternative estimate except as noted in Chapter 4.

Section C.3 Monetary Benefits Timing

[4] U.S. Department of Commerce (DOC) Technology Transfer Report 2004, page 17, and Association of University Technology Managers (AUTM) Licensing Survey FY2002, 15.

[5] AUTM Licensing Survey FY2002, 7.

[6] DOC Technology Transfer Report 2002, 71.

[7] A. Artuso, *Drugs of Natural Origin: Economic and Policy Aspects of Discovery, Development, and Marketing* (Binghamton, New York: The Haworth Press, 1997) 21.

[8] *See* Appendix A, model CRADA, Article 12.4 of this document. The NPS expects that other forms of benefits-sharing agreements would also include a clause in which any obligation for performance-based payments to the NPS would survive termination of the agreement.

[9] Although researchers can realize income related to their research results for a period of time longer than 20 years, this DEIS considers long-term impacts to be any change that is evident after 20 years. Therefore, using a deferred benefits period of 20 years is sufficient to analyze the potential impacts of Alternative B.

Section C.4 License Income Reported by Federal and Academic Research Institutions

[10] Annual reports about income generated by licenses held by federal laboratories are compiled by the DOC. Annual reports about income generated by licenses held by academic institutions are compiled by AUTM.

[11] Neither federal nor academic research institutions report milestone payments or other non-royalty performance-based payments separately from total income, so actual performance-based payments generated under Alternative B may be larger than indicated in the analysis for this DEIS.

[12] The AUTM survey "distinguishes between three sources of License Income: Running Royalties from sale of licensed products; Cashed-In Equity from sale of equity in the licensee received as part of the license consideration; and all other types of license income, such as upfront fees, annual minimum royalties, milestone payments and so forth," (AUTM Licensing Survey 2002, 18). Income attributed to cashed-in equity was removed from analysis because the NPS does not expect to realize any similar income.

[13] The NPS Conservation Planning, Environmental Impact Analysis, and Decision Making Handbook (7) states, "If information important to the decision between alternatives is incomplete or unavailable, you should state this in a NEPA document (CEQ 1502.22)." National Park Service, *DO-12 Director's Order and Handbook*, 2001.

[14] AUTM Technology Transfer Report 2002, 15, 18.

[15] AUTM Technology Transfer Report 1999, i; AUTM Technology Transfer Report 2000, 1; AUTM Technology Transfer Report 2001, 1; AUTM Technology Transfer Report 2002, 1, 15.

[16] From 1999 through 2001, the Department of Interior (DOI) reported between 6 and 11 active licenses annually, all of which were negotiated to obligate royalties. However, the number of licenses that actually yielded royalties was not reported. The DOI did not report any information for 2002–2003 (DOC Technology Transfer Report 2004, 115–117).

[17] U.S. Department of Commerce, *Recent Trends in Federal Technology Transfer: FY1999–2000 Biennial Report,* 29.

Section C.6 CRADA Income Received by Federal Agencies

[18] The terms of the Yellowstone–Diversa CRADA (described in Chapter 1, Section 1.8.1.1 of this document) included an up-front payment totaling $100,000 over a five-year period.

Section C.7 Potential Number of Agreements that Could Be Active Annually in the NPS

[19] Some benefits-sharing agreements could be based on commercial applications for research results (such as contract research, *see* Section C.2 *and* Appendix A of this document) that would not involve an invention.

[20] DOC Technology Transfer Report 2002, 44.

[21] J. Spiegel, Senior Advisor for Technology Transfer Operations, Office of Technology Transfer, National Institutes of Health, pers. comm. to A. Deutch, March 19, 2004.

Section C. 8 Modeling Potential Monetary Benefits

[22] ten Kate (K. ten Kate and S. Laird, *The Commercial Use of Biodiversity: Access to Genetic Resources and Benefit-Sharing* (London: Earthscan Publications LTD, 1999), 252) reports that royalty rates in agreements resulting from the collection of "raw samples" range from 0.05% to 5%, with rates increasing to as much as 8% when the agreement concerns research results such as "active strains/isolates," "gene sequences," and "purified enzymes/proteins."

[23] W. Reid et al., *Biodiversity Prospecting* (Washington, D.C.: World Resources Institute, 1993), 111–112. *See also* E. Anderson, *INBio/Merck Agreement: Pioneers in Sustainable Development* (Cambridge, Mass: Harvard Business School, 1992), 10.

[24] *See, e.g.,* ten Kate and Laird, *The Commercial Use of Biodiversity,* 232: "Estimating the 'market value' or 'global sales' of biotechnology products is extremely difficult. To determine exactly which products have a strong biotechnology component would entail a company-by-company and product-by-product assessment. Not only would these figures be too fragmented and detailed to gather and analyze, but national statistics, figures from trade associations and reports by market analysts do not, as a rule, even estimate them, and may use different definitions when they do."

[25] Global market estimates for 1998 unless otherwise noted.

[26] The global pharmaceutical market also was estimated to be expanding at a 6% annual rate through 2001 (ten Kate and Laird, *The Commercial Use of Biodiversity,* 34).

[27] *Ibid.*, 188, 27.

[28] *Ibid.*, 232.

[29] *Ibid*. The global market for "enzymes" was reported to be U.S.$1 billion in 1989 (H. Zedan, "The Economic Value of Microbial Diversity," *SIM News* 43(5) (September/October 1993), 182).

[30] "Other" specifically includes leather, tanning, metals, and oil fields.

[31] Zedan, "The Economic Value of Microbial Diversity," 232.

[32] *Ibid.*, 232.

[33] *Ibid.*, 42.

[34] *Ibid.,* 183.

[35] ten Kate, *The Commercial Use of Biodiversity,* 194.

[36] DOC Technology Transfer Report, 2004, 74, 82 (Department of Defense, Department of Energy).

[37] DOC Technology Transfer Report 2004, 50, 60, 80, 122 (USDA, Department of Commerce, Department of Energy, NASA).

[38] AUTM Licensing Survey FY2001, 15.

[39] DOC Technology Transfer Report 2004, 50, 60, 74, 82, 102, 108, 116, 122, 130, 136; AUTM License Survey FY2000, 13; AUTM License Survey FY2001, 12; AUTM License Survey FY2002, 20. AUTM License Survey FY1999 did not report the number of licenses yielding royalties of more than $1 million.

[40] The Department of Defense reported that in 2001, one license generated $4.2 million, and that the top 29 revenue-generating licenses also generated $4.2 million. Therefore, no more than one license could have generated more than $1 million (DOC Technology Transfer Report 2002, 23). The Department of Defense had at least one license that yielded more than $1 million in 2002 and 2003, but did not report any other information that could indicate whether more than one license yielded more than $1 million (DOC Technology Transfer Report 2004, 74).

[41] The Department of Energy reported that in 2001, one license generated $1.6 million, and that the top 100 revenue-generating licenses generated $2.7 million. Therefore, no more than two licenses could have generated more than $1 million. The Department of Energy reported that no licenses yielded more than $1 million in 2002 or 2003 (DOC Technology Transfer Report 2004, 82).

[42] *See, e.g.,* M. Milstein, "Firms Milk Park's 'Wildlife,'" *High Country News* 25(24) (December 27, 1993).

[43] Experts have reported that royalty rates associated with agreements resulting from the collection of "raw samples" range from 0.05% to 5%. Rates increase to as much as 8% when the agreement concerns

research results such as "active strains/isolates," "gene sequences," and "purified enzymes/proteins" (ten Kate and Laird, *The Commercial Use of Biodiversity*, 252). Similarly, a study regarding the pharmaceutical industry reported that when an outside source provided research specimens during the early stages of research, the industry paid royalties of 1–5% (Reid et al., *Biodiversity Prospecting,* 111–112. *See also* Anderson, *INBio/Merck Agreement,* 10).

[44] These patents were assigned to government or private institutions.

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